Porous Pavements Increase Above-Ground Growth of *Platanus orientalis*

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Impervious Urban Surfaces

Source: 1. Soil Conservation Service 1975

Impervious Urban Surfaces

- Disrupt hydrological cycle
  - Local flooding, drought, limits evaporation, etc
- Associated with urban heat island effect
- Believed to hinder tree growth and physiology

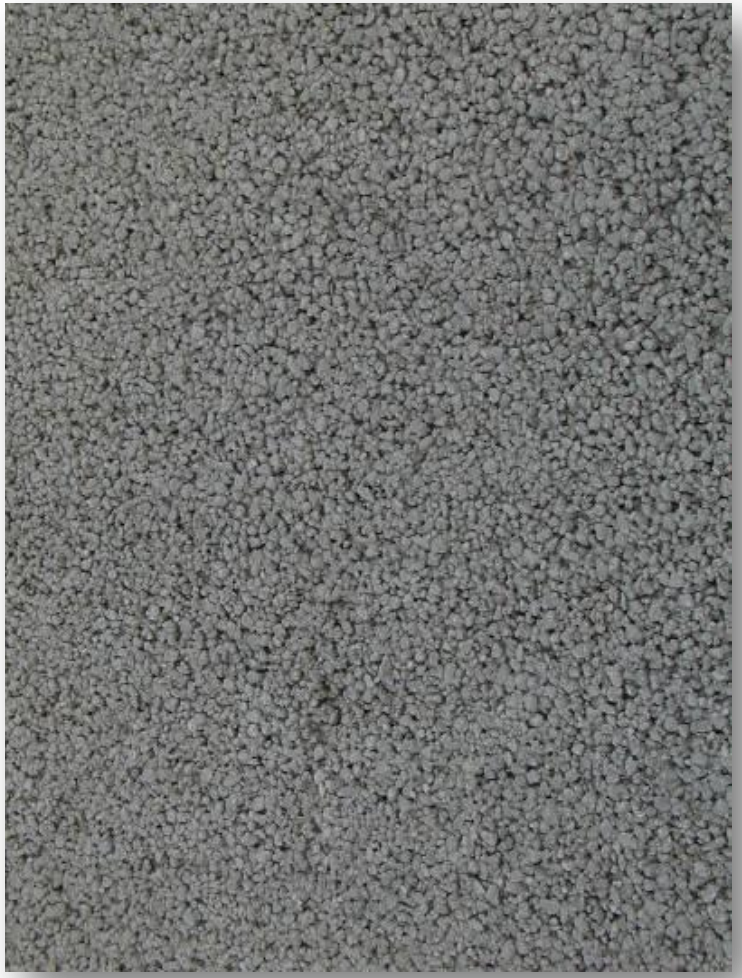
Pavement is Pervasive

- 93% of roads in America unpaved in 1904[2]
- Change came with the ascendancy of the automobile
- Now, >50% of dense urban cores paved[1]

Photo credit: Joel Tauber

Porous Paving

- Monolithic construction:
  - Pervious paving
  - No-fines paving
  - Open-graded paving
  - Gap-graded paving
  - Percolating paving
  - Percrete

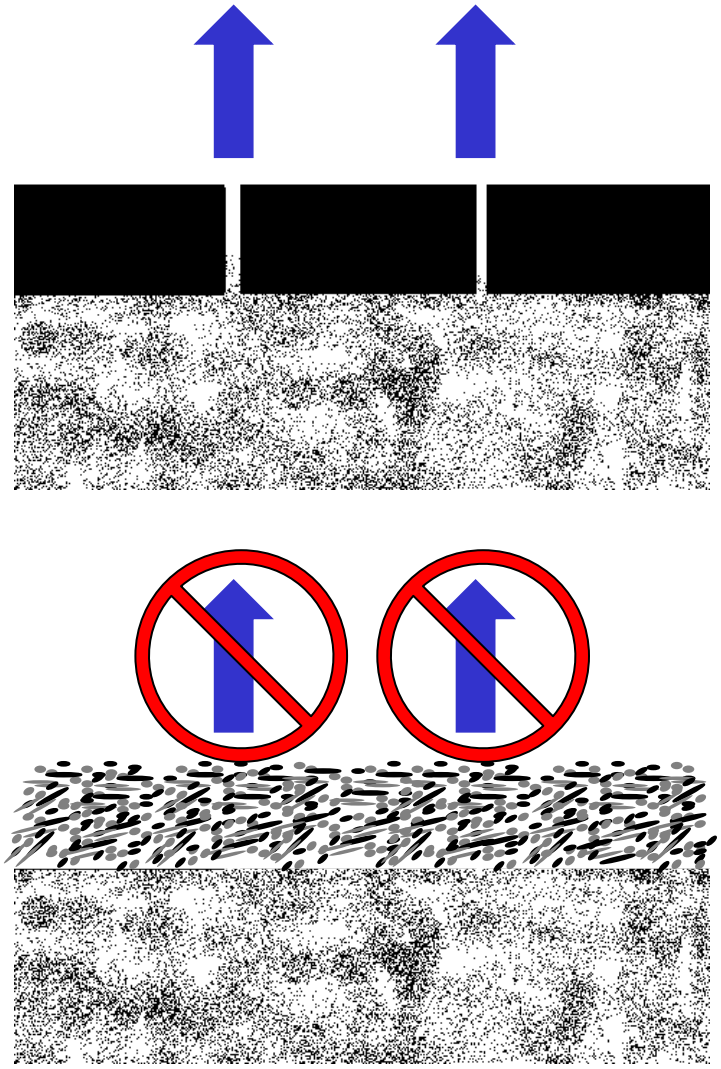


Permeable vs. Porous Paving

- Results apply only to monolithic construction
- Pervious surfaces affect hydrology
  - Infiltration
  - Evaporation
- Infiltration unaffected by porous/permeable
- Evaporation from soil
  - Permeable → direct
  - Porous → indirect

Permeable vs. Porous Paving

- Results apply only to monolithic construction
- Pervious surfaces affect hydrology
  - Infiltration
  - Evaporation
- Infiltration b/w porous and permeable ~ equal
- Evaporation from soil
  - Permeable → direct
  - Porous → indirect



Porous Paving in the Literature

- Search for porous paving on Scopus yielded:
  - **61** articles prior to 1980
  - **67** between 1980 – 1990
  - **118** between 1990 – 2000
  - **409** since 2000
- Research mirrors increased installation of PP

The Motivation

- Too many "factoids"
- Prof. Bruce Ferguson, University of Georgia "***ideal for protecting trees in a paved environment***"[1]
- Tennis et al. 2004, Portland Cement Association "***increase the longevity of trees by improving moisture and oxygen relations***"[2]
- Prof. Vern Schaefer, University of Iowa "***preserving native ecosystems***"[3]
- Where's the proof?

More Motivation

- Is pervious paving 'good' for urban trees?
- Theoretically possible, but we don't know for certain
  - Research has often found unexpected results[4]
- If true, there may be unintended consequences
  - Increased root growth → Increased conflicts

Hypothesis

Across varying pavement profile designs, porous paving affects tree growth relative to standard impervious paving

Experiment Site

Experiment Site – Christchurch, NZ

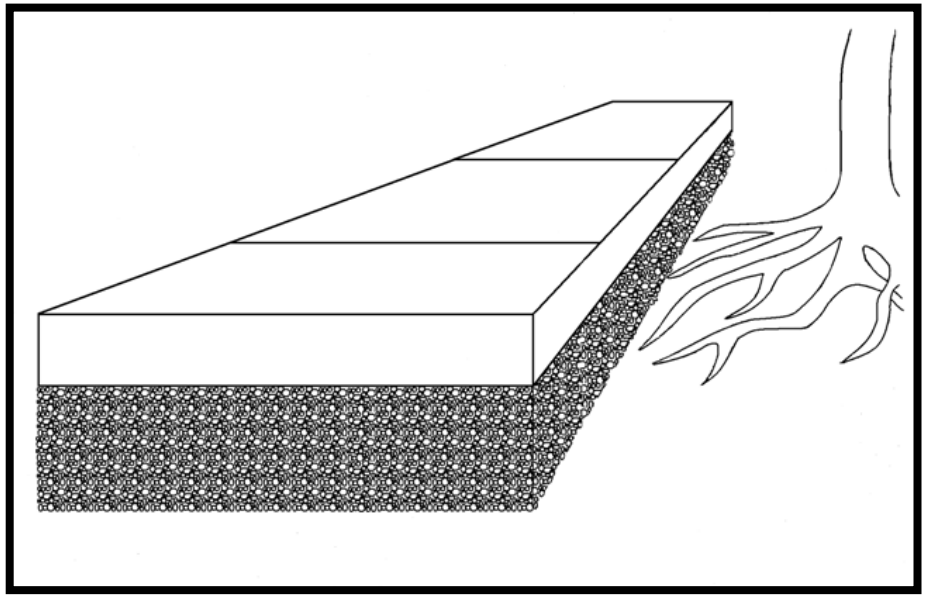
- Population ~ 400,000
- Mean temperature:
  - 10°C in July to 21°C in January
- Mean Annual Rainfall:
  - 600-700mm
  - evenly distributed throughout the year

Treatments

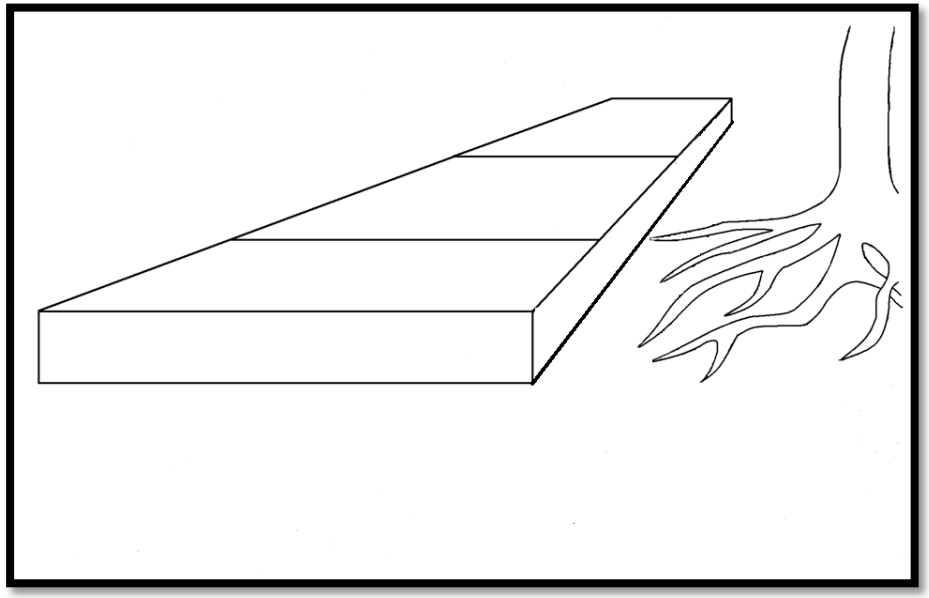
Augmented Factorial Arrangement:

- Control & Pavement Type * Pavement Profile Design
- Pavement Type → Porous, Impervious
- Pavement Profile Design → +/- Compacted subgrade, gravel base

Pavement Profile Design



Structural



Non-Structural

Data Collection

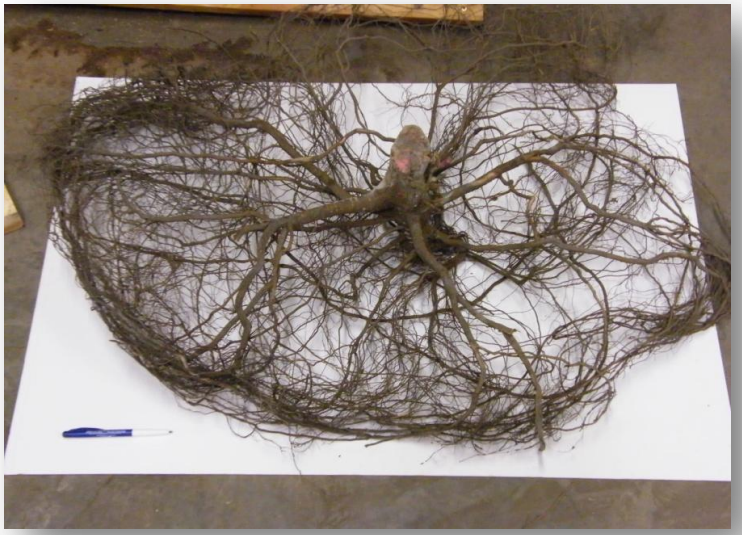
Tree Growth:

- Stem Height
- Stem Diameter
- Shoot/~~Root~~ Biomass
- ~~Root Diameter and Distribution~~

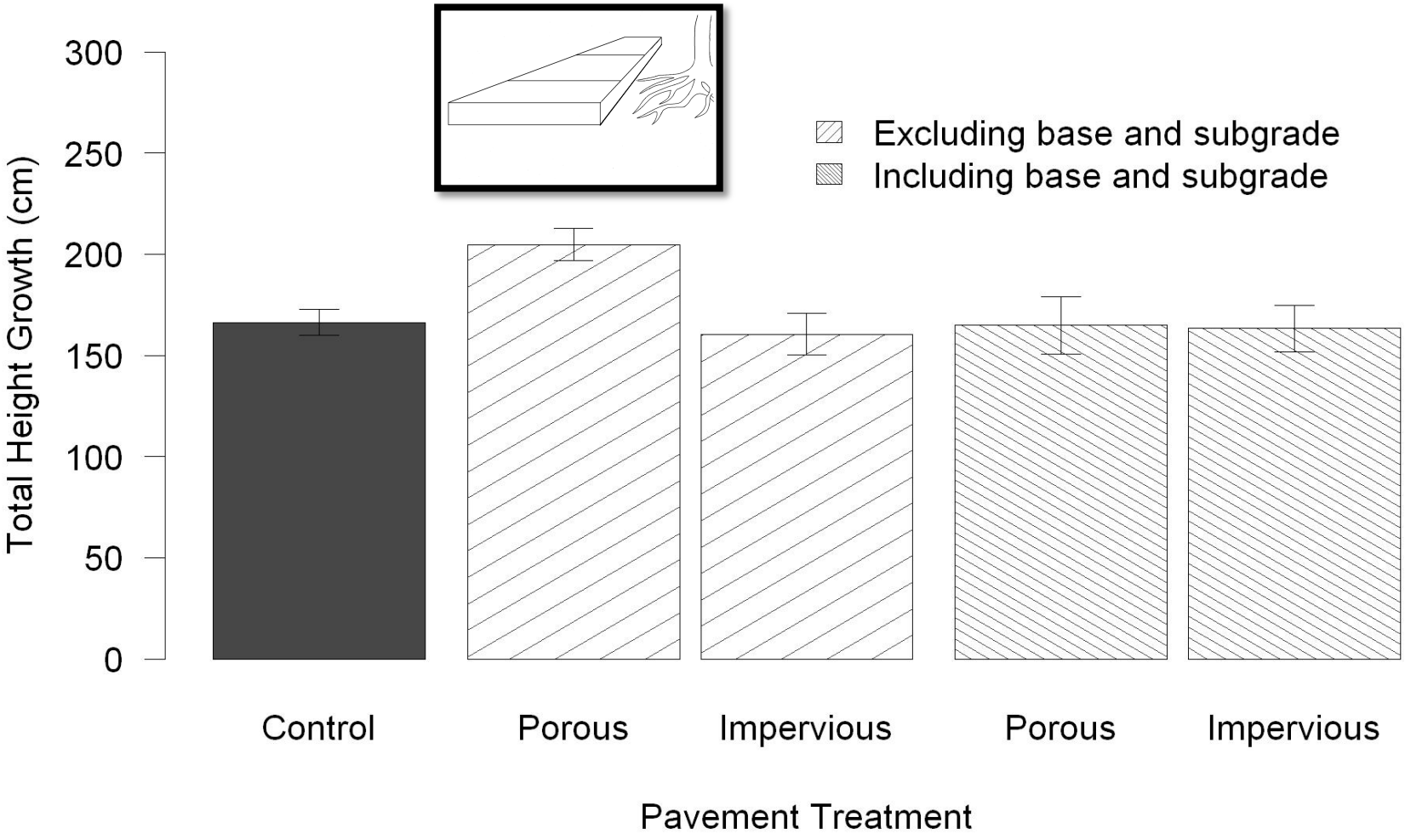
—

~~Edaphic Factors~~:

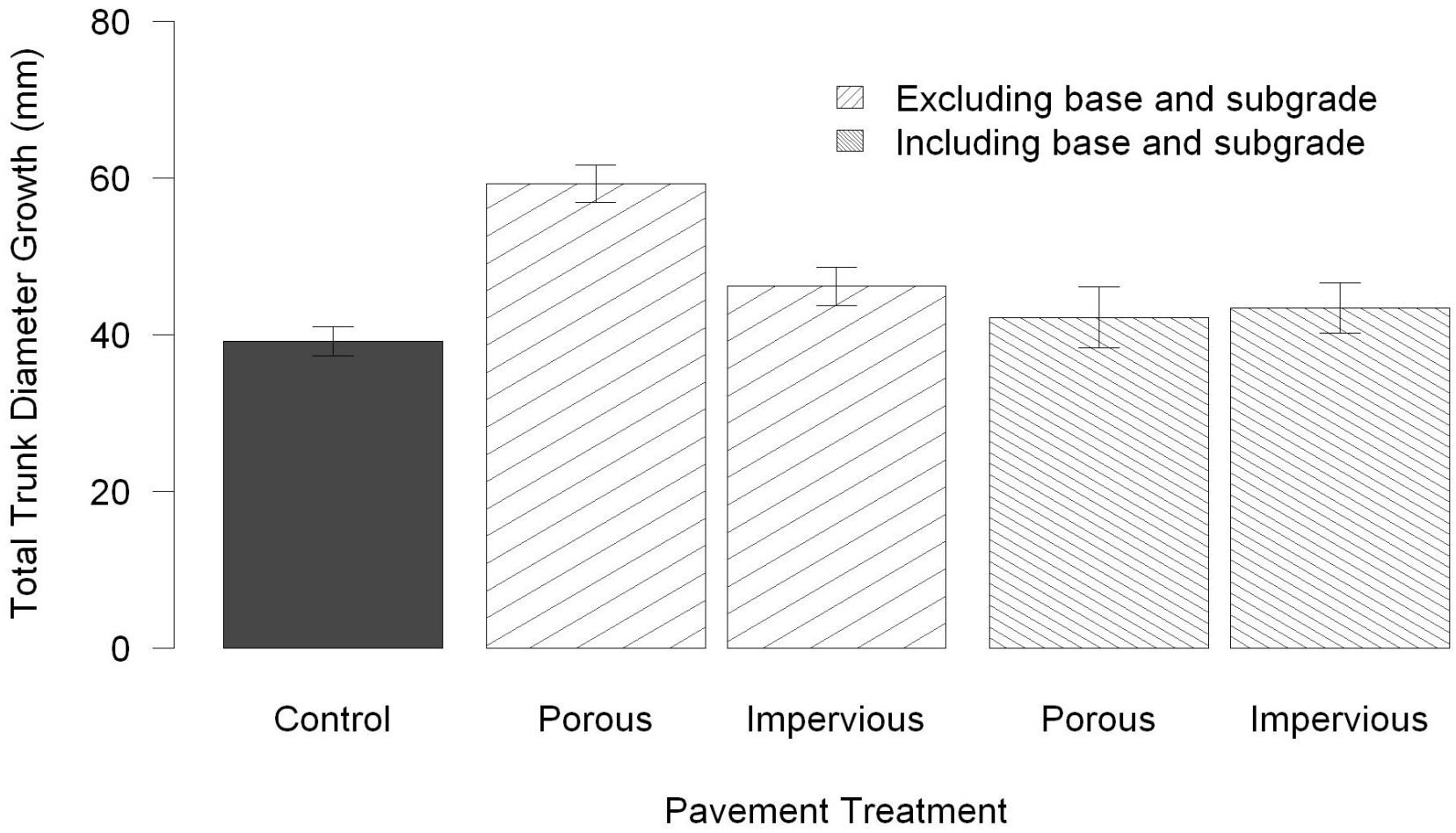
- ~~Water content~~
- ~~Aeration~~
- ~~pH~~
- ~~Nutrient availability~~



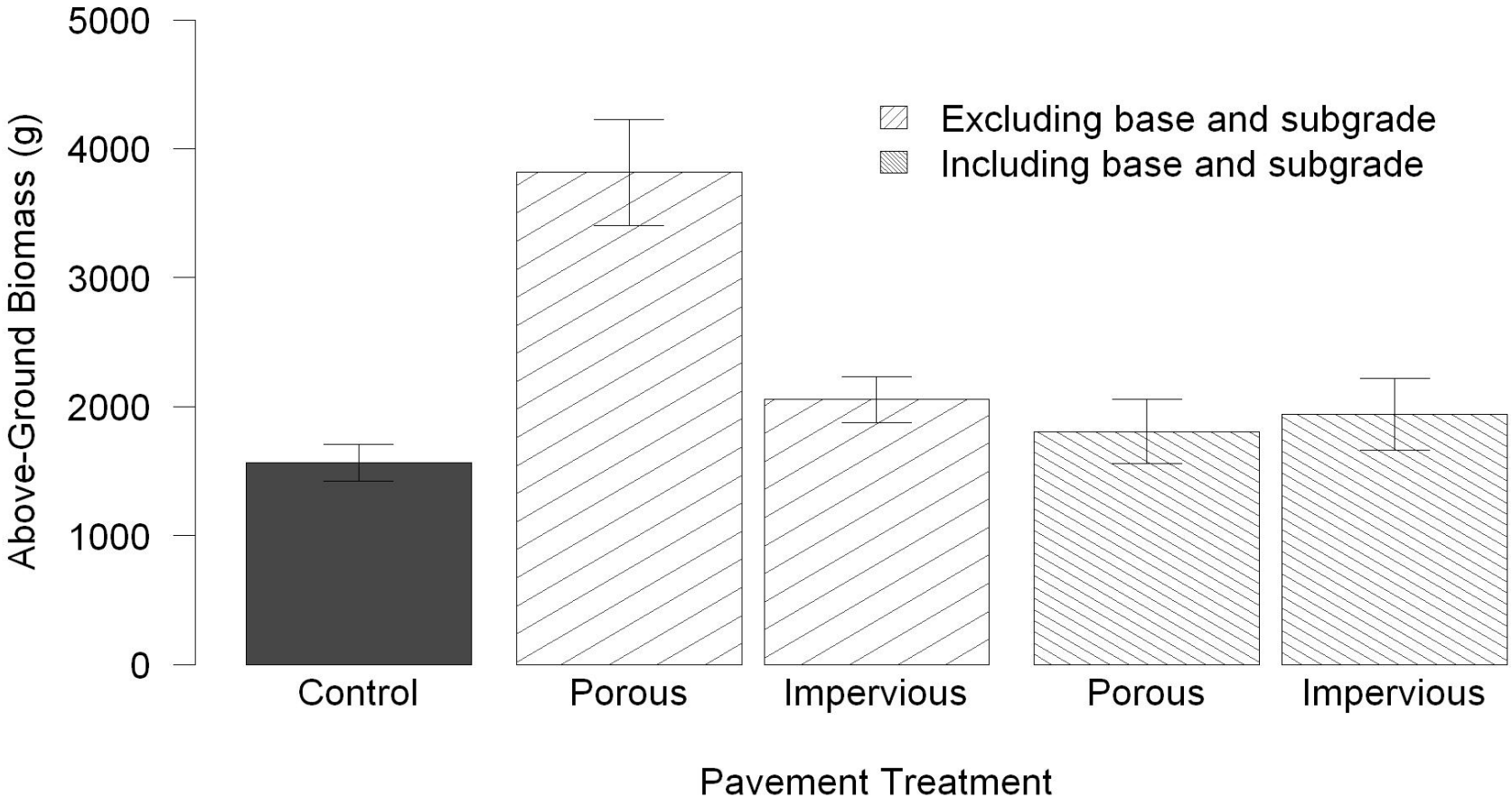
Stem Height Growth



Stem Diameter Growth

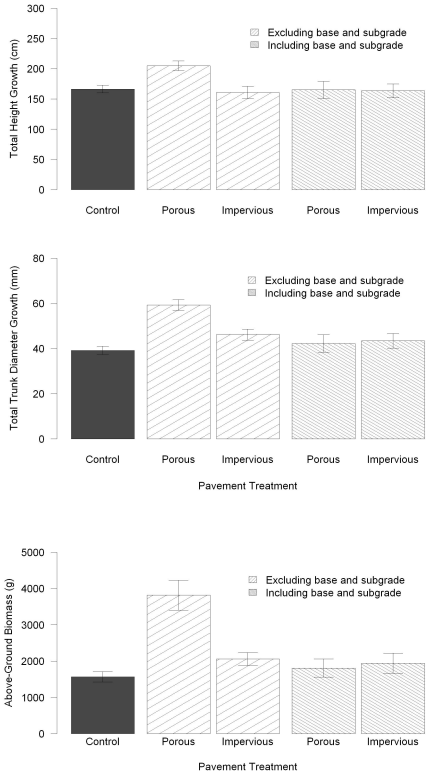


Shoot Biomass



Summary of Findings

- Pavements never reduced any growth attribute relative to controls
- Porous paving yielded greater:
  - Stem height growth
  - Stem diameter growth
  - Above-ground biomass
- True only when pavement profile design excluded structural elements
  - compacted subgrade and gravel base



Implications

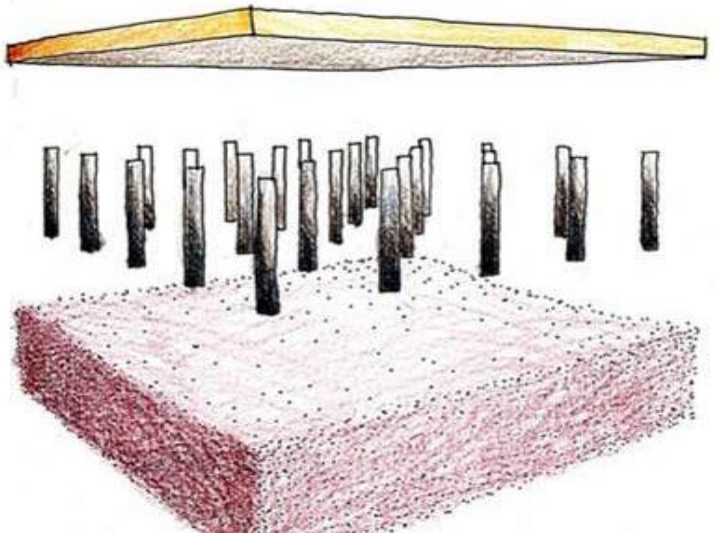
- Pavement often blamed for decreased growth or premature mortality[6,7,8]
- In absence of 'other' stressors, trees surrounded by pavement are not disadvantaged
  - Vandalism, air/soil pollution, soil volume, soil compaction, etc.

Further Implications

- If porous pavement is installed to improve conditions for tree growth, important to remember:
  - Profile design supersedes surface course porosity
- Care for rhizosphere necessary if porous pavement is intended to improve tree growth
- Take care of the soil and the soil will care for the tree

Further Implications

- Porous pavement may be used effectively in conjunction with:
  - Suspended pavements
  - Engineered soils



Further Implications

- Allometry → Increased above-ground growth implies increased below-ground growth
- Greater growth with porous paving not always desirable
- If increased root growth occurs beneath sidewalks → increased incidence of infrastructure conflict
  - Very Expensive Problem

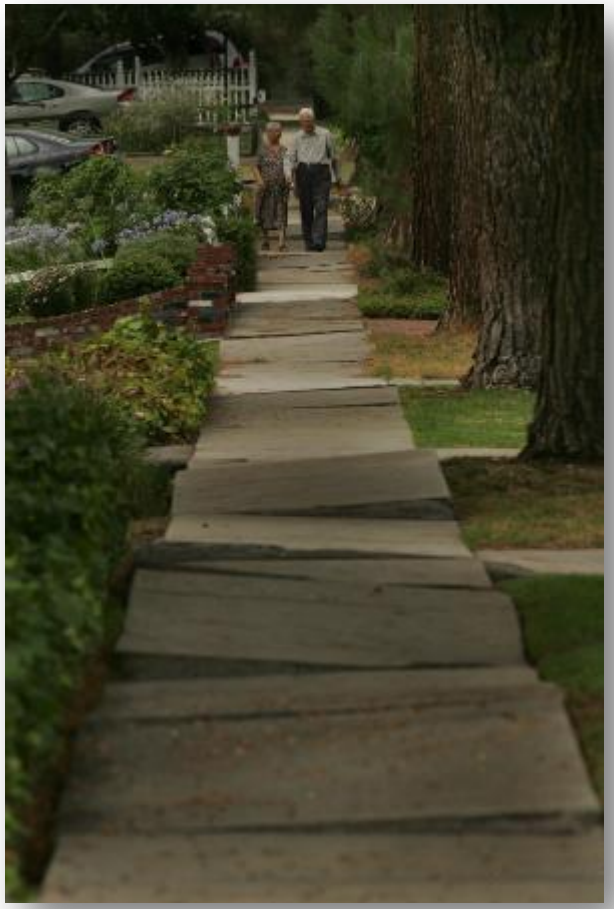


Photo: Cracked, uneven sidewalk along Cabanas Avenue in Tujunga in 2006.
Credit: Richard Hartog / Los Angeles Times

Limitations and Future Research

- 1 tree species
  - *Platanus orientalis* very hardy
- 1 soil type
  - Fine sandy loam
  - Different texture/compaction levels will affect hydrology completely differently
- Size of pavement treatments
  - Results only applicable to small-scale installations
  - Larger sizes would exaggerate response
- Porous v. Permeable
  - Comparision of response to both types

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